NASA SBIR/STTR Technologies

H2.02-9101 - Advanced Zirconium Carbide Tie-Tubes for NTP

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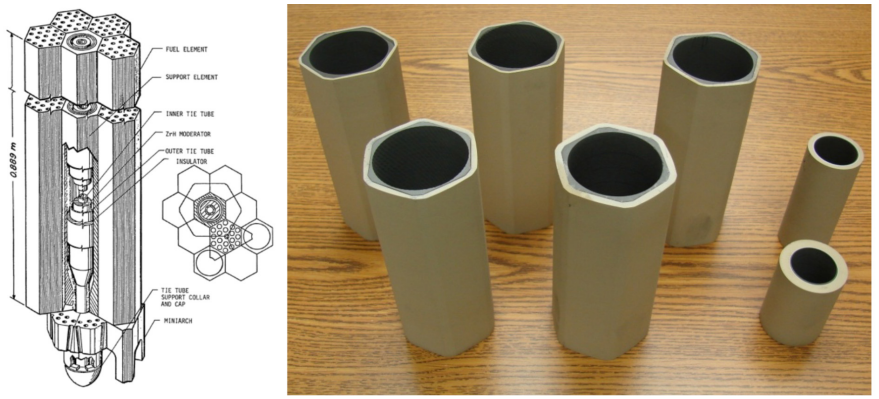
Identification and Significance of Innovation

Nuclear Thermal Propulsion (NTP) has been identified as a critical technology needed for human missions to Mars due to its increased specific impulse as compared to chemical propulsion. However, NTP reactors must operate at extremely high temperatures, and many of the best materials for some reactor components (i.e., support rods, control drums, and the reflector) cannot operate at these high temperatures. Therefore, high temperature insulators are needed. The Rover/NERVA program identified ZrC as a leading candidate for NTP insulators. However, the inherent brittleness and high melting temperature of ZrC make fabrication of complex components such as long, hexagonal tie-tubes extremely difficult. Recently, advanced Vacuum Plasma Spray (VPS) forming techniques have been developed for producing near-net-shape components from Ultra High Temperature Ceramics (UHTC). Building on this success, advanced VPS processing will be developed for producing ZrC tie-tubes for NTP.



A B

Figure 1 – A) Schematic showing NTP tie-tube surrounded by nuclear fuel rods. B) TaC hexagonal and cylindrical tubes produced by Vacuum Plasma Spray (VPS) forming.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 4)

Technical Objectives and Work Plan

- The overall objective is to develop ZrC insulators for NTP reactors. - Near-net-shape VPS processing parameters will be developed to produce ZrC tie-tubes. - To decrease the thermal conductivity of the ZrC material, VPS processing parameters will be manipulated to produce low density, substoichiometric ZrC. - Deposits will be characterized to determine the effect of the different processing parameters on microstructure, phase structure, and chemical composition. - Preliminary testing will be performed to assess the mechanical and physical properties. - High temperature thermal cycle tests will be conduced using an Ar-H2 plasma torch to characterize thermal shock and hot hydrogen resistance. - Using the most promising techniques, demonstrate feasibility by fabricating hexagonal shaped ZrC tubes.

NASA Applications

NASA applications benefiting from this technology include Nuclear Thermal Propulsion (NTP) and Nuclear Electric Propulsion (NEP). Potential NASA missions include rapid robotic exploration missions throughout the solar system and piloted missions to Mars and other destinations such as near earth asteroids.

Non-NASA Applications

Commercial sectors that will benefit from this technology include medical, power generation, electronics, defense, aerospace, chemicals, and corrosion protection. Specific applications include protective coatings, x-ray targets, valves, non-eroding throats and thrusters for propulsion, and crucible/furnace components.

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NON-PROPRIETARY DATA